A review of seal killing practice in Europe: Implications for animal welfare

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1. Introduction

There are various motivations for seal killing in Europe. Some are killed in the name of preventing them from disturbing, damaging, injuring and/or killing commercially-valuable fish at fish farms, in fishing nets and in angling rivers (Butler *et al.,* 2011; Varjopuro, 2011; Nunny *et al.,* 2016). This is the principal reason, for example, for seals being killed under licence in Scotland under the Marine (Scotland) Act 2010 (MSA2010) with licences being issued "to prevent serious damage to fisheries and fish farms" and "to protect the health and welfare of farmed fish" (The Stationery Office, 2010; Marine Scotland, 2015). Predator control is also considered necessary in some places for preventing the escape into the wild of farmed fish (Butler *et al.,* 2005). In Scotland, seal management has also had to take into consideration the required protection of Atlantic salmon (*Salmo salar*), common seals (*Phoca vitulina*) and grey seals (*Halichoerus grypus*) under the European Union (EU) Habitats Directive (Butler *et al.,* 2006; Butler *et al.,* 2015).

Some European nations permit seal killing for commercial reasons to sell the skin, blubber and meat for profit (EFSA, 2007). Norway, Greenland and Russia carry out commercial hunts targeting harp seals (*Pagophilus groenlandicus*), and Greenland's hunters, many of whom are considered traditional subsistence hunters, also target bearded (*Erignathus barbatus*), hooded (*Cystophora cristata*) and ringed seals (*Pusa hispida*) as well as walruses (*Odobenus rosmarus*) (EFSA, 2007; Ministry of Fisheries, Hunting and Agriculture, 2012). Within the EU, seal products can only be placed on the market if they result from a hunt conducted by Inuit or other indigenous communities, if the hunt has been traditionally carried out by the community, if it contributes to the subsistence of the community and is not carried out for commercial reasons and if it "has due regard to animal welfare" (European Parliament 2009 and 2015). The EU Regulation on the trade in seal products has not prevented seal hunting in some places, for example Finland, but does mean that seal export markets cannot be developed (Meek *et al.,* 2011).

Seal hunting is a recreational activity in some regions and seals are regarded as game animals meaning that, even if they are killed for management reasons, the carcase may be collected for the personal use of the hunter. This occurs for example in Åland (an autonomous Swedish-speaking province of Finland), Finland, Greenland, Norway and Sweden (Baltic Marine Environment Protection Commission, 2014; EFSA, 2007; Meek *et al.,* 2011; Ministry of Agriculture and Forestry, 2007; Ministry of Fisheries, Hunting and Agriculture, 2012).

This paper reviews seal killing methods across Europe; open and close seasons; training requirements; and how seal killing is monitored, including whether carcases are collected and assessed to establish the likelihood of a humane death.

Based on our results, we identify weaknesses in management and legislation which deserve further consideration if animal welfare is to be improved.

2. How seals are killed

2.1 Killing methods

Firearms are the most commonly used tool for killing seals. Rifles are used to shoot seals in commercial and recreational hunts and in management situations. There is, however, no harmonised international standard specifying which firearms and ammunition should be employed (NAMMCO, 2009).

In Scotland, the type of firearm which can be used to kill seals is "a rifle using ammunition with a muzzle energy not less than 600 foot pounds and a bullet weighing not less than 45 grains" (Marine Scotland, 2011). England and Wales have the same stipulation (The Stationery Office, 1970). All .22 rimfire rifles are excluded (Marine Scotland, 2011).

In Scotland, England and Wales bullets must weigh at least 45 grains (2.9g), whilst in other places, heavier ammunition is required for shooting seals. For example, in Åland, Finland and Sweden, bullets should weigh at least 3.2g whilst in Denmark, Estonia, Norway and Svalbard they should weigh at least 9g. Some of these differences may reflect differences in sizes of the animals being shot. The impact energy of the bullet is specified in some hunting regulations. In Scotland, England and Wales this must be at least 600 foot-pounds (813.5 joules) (Marine Scotland, 2011; The Stationery Office, 1970). In other countries it ranges from 160 joules (Greenland) through 800 joules (Åland, Finland, Sweden) to 2,700 joules (Denmark, Norway, Svalbard). See Table 1 for further details and references.

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Devices other than firearms are used in some countries. In the Norwegian commercial hunt, most adult harp seals are shot with a rifle, while a strike from a hakapik (a club with a spiked end – see below) or a slagkrok (an iron club with a sharp hook which is used to kill pups) are also accepted methods (EFSA, 2007; Norwegian Scientific Committee for Food Safety, 2007).

The Canadian hakapik is described / prescribed in the Canadian Marine Mammal Regulations (Government of Canada, 2015), as;

'An instrument…, consisting of a metal ferrule that weighs at least 340g with a slightly bent spike not more than 14cm in length on one side of the ferrule and a blunt projection not more than 1.3cm in length on the opposite side of the ferrule and that is attached to a wooden handle that measures not less than 105cm and not more than 153cm in length and not less than 3cm and not more than 5.1cm in diameter.'

The Norwegian hakapik is similar, with a metal ferrule weighing at least 400g with a 12-18cm spike and a blunt projection of no more than 4cm in length. The ferrule is attached to a wooden handle 110-150cm long (Norwegian Scientific Committee for Food Safety, 2007). Once a seal has been shot or struck with the blunt end of the hakapik, the sharp end is used to strike the seal to make sure that it does not regain consciousness before it is bled out (EFSA, 2007). The sharp end of the slagkrok can be used as an alternative to the hakapik on pups that are younger than one year old (EFSA, 2007). Hakapiks and rifles are also used in Russian commercial hunts (EFSA, 2007).

The seal must be bled out immediately thereby preventing blood from flowing to the brainstem and ensuring death (EFSA, 2007; Fiskeridirektoratet, 2003). The Canadian Marine Mammal Regulations (Government of Canada, 2015) provide, as an example, specific guidance on exsanguination;

'No person shall skin a seal until the cranium has been crushed and at least one minute has elapsed after the two axillary arteries of the seal located beneath its front flippers have been severed to bleed the seal.'

This is intended to ensure that the animal, which has been stunned or concussed, then progresses to death by blood loss, without the potential for a return to consciousness, and aligns with procedures required by slaughter legislation for farmed animals in slaughterhouses - for example in Council Regulation (EC) No 1099/2009 of 24 September 2009 on the protection of animals at the time of killing;

'The loss of consciousness and sensibility shall be maintained until the death of the animal' (European Council, 2009).

Exsanguination is achieved by turning the seal onto its back and making a cut from under the jaw to the sternum, followed by incisions down both sides of the thorax so that the brachial arteries and other associated arteries can be cut (Norwegian Scientific Committee for Food Safety, 2007).

In Iceland, grey seal pups are killed with clubs or rifles, whilst common seal pups are first caught in nets before being killed with a seal club or shot with a .22 calibre rifle (NAMMCO, 2016b). Netting is also used to hunt ringed seals in Greenland and Russia (COWI, 2008; EFSA, 2007). From October to March, ringed seals are caught in Greenland using nets because the darkness and the ice conditions are considered likely to make other methods unfeasible (COWI, 2008; Ministry of Fisheries, Hunting and Agriculture, 2012; Garde, 2013). In North Greenland, a third of hunted ringed seals are caught using nets (Ministry of Fisheries, Hunting and Agriculture, 2012). In Russia, different types of nets are used in the Chukotka region depending on the season, with long tangle nets being used in the summer, and shorter nets in the winter, when they are placed across ice fractures or below seal breathing holes (EFSA, 2007). Use of nets is effectively outlawed in the UK by the Conservation (Natural Habitats, &c.) Regulations 1994 which prohibit the taking or killing of mammals using *"nets*

which are non–selective according to their principle or their conditions of use" (The Stationery Office, 1994).

The serious injury workshop held by the National Oceanic and Atmospheric Administration (NOAA) in 2007, classified entanglement and subsequent asphyxiation as being in the 'severest' classification for the welfare impact on seals entangled in marine waste – and this is analogous to intentional netting (NOAA/NMFS, 2007). In Russia, seal traps which hold the seal underwater until it dies are used in rivers (EFSA, 2007).

In Finland and Sweden, traps are permitted for the live capture of grey seals which are then killed with a shot to the head (Ministry of Agriculture and Forestry, 2007; Lehtonen and Suuronen, 2010; Mörner *et al.,* 2013; Oksanen *et al.,* 2015). In walrus hunting in Greenland, it is compulsory to harpoon the walrus before firing the shot which will kill it, to prevent the animal from sinking (NAMMCO, 2016b) or, presumably, escaping wounded. However, it is also common to shoot the animal in the body to slow it down, then to harpoon it before delivering the final shot (NAMMCO, 2016b).

2.2 Location (land/ice or water) of seal at time of killing

In some countries, legislation or common practice dictate whether seals should be on land or ice or in water when they are shot (see Table 2). Denmark and Scotland are the only countries that do not allow seals to be killed on land (Marine Scotland, 2015 and 2017; Miljø- og Fødevareministeriet, 2016). In Denmark, this is because seals are shot when they are sighted close to fishing gear (Miljø- og Fødevareministeriet, 2016). In Scotland, a seal licence may impose conditions such as the area and circumstances in which seals may be killed; which may include the area around a fish farm, salmon net fishery or an area within a salmon river system (The Stationery Office, 2010; Marine Scotland, 2011). The protection of seals at haul-out sites is included in the Scottish legislation (The Stationery Office, 2010) and seal management in Scotland aims to balance seal conservation with fisheries protection and tourism (Butler *et al.,* 2008).

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2.3 Position of marksman

The Scottish Seal Management Code of Practice states that seals "*must not be shot from an unstable platform*" but that they should be shot "*from an elevated position*" if possible (Marine Scotland, 2011). In Åland, seals cannot be shot from boats, whilst in Sweden and Denmark they can be shot from stationary boats (Miljø- og Fødevareministeriet, 2016; Ålands landskapsregering, 2017; Swedish Environmental Protection Agency, 2017a). In Greenland, harp seals are shot in the water from boats, whilst the "uuttoq" hunt for ringed seals involves the hunter approaching the seals on the ice using a screen and shooting them at close range (Ministry of Fisheries, Hunting and Agriculture, 2012). In Scotland, seals must be shot from no further than 150 metres (Marine Scotland, 2011).

EFSA (2007) states that firearms should be used from appropriate distances but without specifying what these are. Most countries do not specify how close a hunter should be to the seal before firing.

2.4 Open and close seasons

Most countries in Europe that kill seals have open and close seasons. Ringed seals in Svalbard, for example, are protected during their breeding seasons and Norway prohibits the hunting of female adult hooded and harp seals and unweaned harp seal pups at breeding sites (Fiskeridirektoratet, 2003; Norwegian Scientific Committee for Food Safety, 2007; Kovacs, 2014). In Sweden, hunting is prohibited in some areas when aerial surveys of the seal populations are being conducted in the spring and, in Denmark, open seasons are more restrictive in areas close to breeding sites (see Table 3 for details and references).

Scotland, the Faroe Islands, Iceland and Greenland do not specify any close seasons for seals (although Greenland does have close seasons for walruses) (NAMMCO, 2016ac; Granquist and Hauksson, 2016; The Stationery Office, 2010). Some species in Greenland, such as ringed and bearded seals, are hunted more frequently in winter and spring, whilst hooded seals are hunted year-round (Merkel *et al.,* 2012). In Greenland, the females of all species are protected when they are lactating, as are their pups, although this is not transposed into law via specified close seasons (Garde, 2013; NAMMCO, 2016b). Similarly, the MSA2010 states that a seal licence may impose conditions including "*any period during which seals may not be killed or taken, for example, when females…are likely to be in an advanced stage of pregnancy or have dependent pups*" but no specific dates are given in the law itself and any restrictions are only included on individual licences (The Stationery Office, 2010). Such a restriction may refer, for example, to the maximum number of seals that may be shot between particular dates at specific sites (Marine Scotland, 2017a). Prior to the introduction of the MSA2010, close seasons were in place for both grey and common seals in Scotland under the Conservation of Seals Act 1970, and these close seasons are still applicable in England and Wales (The Stationery Office, 1970 and 2010).

Though close seasons are usually related to breeding seasons, in Norway and Finland, seasonal closures may be introduced when seals are likely to sink after death (NAMMCO, 2006). It should be noted that even when a close season is specified in the legislation, in many countries seals may still be killed during close seasons if they are interfering with fishery or fish farm interests. These derogations are listed in Table 3.

Table 3 here

2.5 Training and testing of marksmen

Denmark, Estonia, Norway (for both the commercial and coastal hunts), Svalbard and Sweden all require marksmen to have undertaken some kind of training, or to have passed a 'shooting test' before they can shoot seals (Fiskeridirektoratet,

2014; Naturstyrelsen, 2016; Norwegian Ministry of Climate and Environment, 2002; Riigikogu, 2013; Svenska Jägareförbundet, 2018; Swedish Environmental Protection Agency, 2017a;). In Norway and Svalbard, hunters must pass a shooting proficiency test every year (Norwegian Ministry of Climate and Environment, 2002; EFSA, 2007). In Åland and Finland, specific shooting tests for seal hunting are not yet in place and the only requirement is that hunters have the relevant licenses and permits (Ålands landskapsregering, 2016a; Suomen Riistakeskus, 2018).

In the Norwegian commercial hunt, the master of the vessel is required to attend an annual training course for seal hunters run by the Directorate of Fisheries, and his crew has to complete the course every two years (EFSA, 2007). In Svalbard (which has its own environmental law), and in the Norwegian commercial hunt, only the same weapon(s) as those used during the shooting test can be used by the hunter concerned to kill marine mammals (Fiskeridirektoratet, 2003; Norwegian Ministry of Climate and Environment, 2002). The annual test for marine mammal hunters in Svalbard involves completing 30 documented training shots plus 5 shots with the appropriate hunting ammunition on a fixed target from a distance of at least 100m and all shots must hit the inner (30cm diameter) target (Governor of Svalbard, 2016).

To kill grey seals in the Danish region of Bornholm only specially trained hunters who have passed a theory and practical test can shoot seals (Christensen, 2016). Conversely, in Iceland, no specific requirements are made regarding training for seal hunters (Sellheim, 2015). In the Faroe Islands, legislation relating to weapons requires participation in a training course but this is not specific to seal shooting (NAMMCO, 2016b). In Greenland, no training courses exist and hunters learn how and where to shoot seals and walruses from other hunters (NAMMCO, 2016b).

Marksmen in Scotland must complete the Seal Management Professional Development Award which includes a self-study online course and a practical shooting test (The Stationery Office, 2010; North Highland College, 2016). Those already holding a Deer Stalking Certificate Level 1 qualification are exempt from the shooting test (North Highland College, 2016). The marksmanship test requires applicants to place three shots inside a 4-inch target at a distance of 50m and 100m (SQA, 2011). Seal licences must only be granted to a person who "*has adequate skills and experience in using firearms*," (The Stationery Office, 2010).

2.6 Monitoring of seal killing

Calculating exactly how many seals are shot is challenging because official figures cannot be independently verified and reporting procedures vary in their efficiency. Table 4 gives the number of seals reported as shot in Europe from 2011 to 2016.

Table 4 here

Fish farms in Norway are required to report all seals shot, but few reports are actually made to the appropriate reporting body (the Directorate of Fisheries)(NAMMCO, 2016a). Grey and common seals killed by recreational fisheries and commercial gill net fisheries are also rarely recorded in Norway (NAMMCO, 2017b). Catch data from Svalbard has only recently been presented to NAMMCO but, unfortunately, it was not included in the last annual report and, therefore, is also missing from Table 4 (NAMMCO, 2017c).

In the Faroe Islands, there is no management plan for seals and fish farms, and fish farmers are allowed to shoot as many seals as they consider necessary (NAMMCO, 2016a). In 2009, the NAMMCO Scientific Committee recommended that fish farms in the Faroe Islands should record the number of seals killed at their sites, but the largest company (which holds 21 of the 35 fish farm licenses) has, so far, failed to report the number of seals they have taken and, therefore, the total number of seals killed can only be estimated (NAMMCO, 2016a). NAMMCO states that although it is possible that some seals are killed away from fish farms and go unreported, these 'takes' are likely to be low (NAMMCO, 2016a). In Greenland, hunters must report their walrus catches including sex, age class and date of killing (Wiig *et al.,* 2014). Catch data for other pinniped species in Greenland is not always reliably reported (NAMMCO, 2016c).

In Iceland, there is no reporting requirement for killed seals (other than animals bycaught in fisheries), although some members of the Seal Farmers Union report their catches and the Icelandic Seal Center receives data from some hunters (NAMMCO, 2016a). The Marine Research Institute publishes some data, but the figures include both hunting and bycatch and, in some cases, the species is not identified (see Table 4). It is unclear how many seals are killed around Icelandic fish farms although the NAMMCO Coastal Seals Working Group suggests that only two or three are killed each year (NAMMCO, 2016a). Common seals which are hunted in Iceland are not officially reported but it is suspected that approximately 300 are killed per year (NAMMCO, 2016a).

In England and Wales, there is no requirement under the Conservation of Seals Act 1970 to report the numbers of seals killed (SCOS, 2017). In Northern Ireland, seals shot under licence are reported to the Marine and Fisheries Division of the Department of Agriculture, Environment and Rural Affairs (Department of Agriculture, Environment and Rural Affairs, personal communication). In Scotland, licence holders must report to Marine Scotland within 10 days of the end of each reporting period how many seals have been killed and/or injured and, if no seals were killed, this should also be reported (The Stationery Office, 2010).

Fish farms in Scotland that are part of the Royal Society for the Prevention of Cruelty to Animals (RSPCA) Freedom Food scheme are required to keep records of any shooting events and to report them to the Freedom Food office within 72 hours (RSPCA, 2015). Records must include the name of the marksman, details of the ammunition used, the reason for the shooting, the number of fish on site and the number of fish killed before the decision to take lethal measures was taken, which species of seal has been shot, and the time, date and location of the

shooting (RSPCA, 2015). Seal carcases should be collected in Scotland so that they can be examined to assess whether the animal's death was "*almost instantaneous*" and that it did not suffer, as well as to analyse stomach contents to determine what the seal had been feeding on (The Stationery Office, 2010; Marine Scotland, 2015).

In Denmark, shot seal carcases should be submitted to the local State Forestry District for scientific study (Skov- og Naturstyrelsen, 2005). The Danish Nature Agency (Naturstyrelsen) will pay DKK 500 for the carcases of grey seals that are shot in the Bornholm region and that are given to the local state wildlife manager (Miljø- og Fødevareministeriet, 2016). In Estonia, samples are collected to determine the health status, age and gender of the shot seals (Ministry of the Environment, 2018a). Hunters in Åland are also encouraged to take samples (Ålands landskapsregering, 2017). In Finland, quotas for seal hunting are set and monitored by the Ministry of Agriculture and Forestry and samples of teeth, genitals and blubber are taken from seals killed by hunters to study seal health, their impact on fish populations and the structure of the seal populations (Luke, 2018).

In Sweden, compensation is paid to those who submit seal carcases or samples from shot seals to the Naturhistoriska Riksmuseet (Swedish Museum of Natural History) (Swedish Environmental Protection Agency, 2016). Samples taken include internal organs, a section of jaw, a piece of blubber with the skin attached, muscle and reproductive organs and, in some circumstances, the whole seal carcase is submitted, for example in the case of ringed seals (Moraeus *et al.,* 2016; Swedish Environmental Protection Agency, 2016). Samples are examined to determine the health status of the seal, its age, diet and, in the case of female seals, gestational state (Moraeus *et al.,* 2016). Compensation of between 600SEK and 2630SEK is paid for each seal depending on which samples are submitted (Swedish Environmental Protection Agency, 2016). In the Norwegian coastal hunt, in some years, compensation has been paid for the submission of grey and common seal jaws to the Institute of Marine Research in Tromsø but, in 2017 and 2018, compensation (of 250NOK) was only paid to hunters for tags recovered from hunted seals (Fiskeridirektoratet, 2017).

The MSA2010 states that *"a seal licence…must impose conditions about the recovery of carcases"* (The Stationery Office, 2010). The Scottish Seal Management Code of Practice requires that the licence holder "*must take all reasonable steps to recover the carcases of shot seals*" and that the details of carcases should be reported to the Scottish Marine Animal Stranding Scheme (SMASS) at the Scottish Agricultural College (Marine Scotland, 2011). The RSPCA (2015) also specify in their welfare standards that *"all attempts must be made to recover the body of the animal that has been shot".*

Commercial seal hunts may be monitored to some extent. For example, Greenland's seal and walrus hunts are monitored by wildlife officers who check hunting permits on land and carry out random checks at sea and, in the Norwegian commercial hunt, experienced veterinarians are present on all

sealing vessels to monitor the hunt as well as assessing the quality of the meat for the Food Security Authorities (NAMMCO, 2017a)

3. Discussion

This review shows that a variety of methods are used across Europe and in neighbouring countries to kill seals and that there is no harmonisation or international standardisation. Some work has been undertaken to develop recommendations for best practice (NAMMCO, 2009) but this has not been transposed into legislation. Some of the variation in methods may relate to cultural and historical factors, the locations involved (including the climatic and geographical conditions), and the time of year. The reasons that the seals are being killed may also affect methods (Broom, 2007). Another important factor is the difference in size of the animals being killed (for example the average weight of adult walruses killed in Greenland differs greatly to that of common seal pups killed in Iceland).

This discussion does not attempt to cover all the issues and conflicts that arise when different cultures and attitudes are confronted with modern day animal welfare concerns, but instead looks at how an individual seal's welfare may be impacted by the killing methods employed. It is also worth remembering that the removal of one animal may have consequent welfare impacts on other seals due to changes in social structure or, in the case of lactating females, because of the mother-pup dependency bond (see section 3.3 'Open and close seasons').

3.1 How seals are killed

To evaluate how a particular killing method affects the welfare of the animals involved, both the 'typical effects' and the 'worst-case scenario effects' should be taken into consideration (Dubois *et al.,* 2017). The majority of seals killed intentionally by European nations are shot using rifles. When an animal is shot effectively and becomes insensible to pain immediately, there is no welfare problem for this particular animal and this can be considered a humane killing method (Broom, 1999). Gregory (2003) considers shooting an animal at close range in the head to be one of the most humane killing methods available, although the accuracy of the shot is of critical importance. For a quick kill, the skill of the marksman is key (Bonner, 1993) and the Scottish Seal Management Code of Practice, for example, states that, when killing a seal, the shot should aim to achieve a "*rapid death*" and to minimise suffering, and details various criteria for how this should be achieved (Marine Scotland, 2011). However, the Code does not address how to check the state of consciousness of a shot seal nor does it specify what a "*rapid death*" is in terms of time to death. Nunny *et al.*(2016) reported that some seals shot in Scotland did not die immediately.

If the animal is not hit in the target area and experiences non-lethal wounding, shooting can cause severe and prolonged potential for distress (Broom, 1999; OIE, 2017). The problems resulting from non-lethal wounding could include suffering from the disabling effects of the injury, from sickness caused by an infection of the wound and from the pain caused by the wound (Gregory, 2003).

A disabling injury may prevent the animal from escaping threatening situations, feeding properly and/or performing specific functions depending on the area of the body that is injured (Gregory, 2003).

Studies looking at hunting of terrestrial mammals have found that a number of animals are likely to be injured rather than killed outright during a hunt. Aebischer *et al.* (2014) reported that 1-12% of shot deer were wounded, and Fox *et al.*(2005) found that in the shooting of foxes (*Vulpes vulpes*), even in the best case scenario, the probability of a kill is 90% with an 8% chance of serious wounding and 2% chance of light wounding. There is evidence that in Scotland some seals killed under the licensing system were not killed by the first shot (Nunny *et al.*, 2016). Butterworth *et al.* (2007) also reported that in the Canadian commercial seal hunt, 82% of shot seals were not killed by the first shot, concluding that shooting was not an efficient killing method under hunt conditions.

Shooting a seal in the head with a lower calibre rifle (below .243) frontally, rather than laterally, causes less damage and may not render the animal immediately unconscious (Brownlow, 2016). Indeed, experts advise that to accurately shoot a seal, the shot should enter the side of the head between the eye and ear, which is where the skull is thinnest (Reilly, 2001; EFSA, 2007). The Scottish Seal Management Code of Practice specifies that seals should be shot in the head but does not state from which angle the shot should be placed (Marine Scotland, 2011). The lack of precision in this guidance is something that could, potentially, undermine the effectiveness of the shot.

Rifle calibre and the type of bullet used can have an impact on animal welfare as they influence the efficiency of the shot (Littin and Mellor, 2005). At present there is considerable variation in the firearms and ammunition used. Some studies have looked at which calibres are the most appropriate for humanely killing seals. When shooting a grey seal at close range (2-3 metres), rifles with calibre .222 or larger, 5.6mm bullet diameter or larger and a .12 shotgun loaded with a slug all caused immediate death (Mörner *et al.,* 2013). It is not clear whether these results can be applied to seals shot from a greater distance. Reilly (2001) recommends a .22 calibre rifle used at close range for euthanasia of pinnipeds. In the Canadian harp seal hunt in 2009, Daoust and Caraguel (2012) reported that .223-calibre and .222-calibre ammunition caused a similar amount of trauma. Brownlow (2016) stated that .308 Remington 125 grain core-lokt pointed soft point ammunition appeared to cause immediate death in grey seals, as did a 12 bore shotgun (though he recommended that this should only be used at a distance of 5m or less for humanely dispatching an animal).

The study carried out by Brownlow (2016) for Marine Scotland used dead seal heads which meant there were limitations to the approach when making comparisons to 'field' situations, and further investigation would be useful. Daoust and Cattet (2004) noted that there are differences in the skulls of seals of different species and that studies to determine what ammunition is appropriate need to be species-specific as well as age-specific.

A study by Hampton *et al.* (2016), which considered the shooting of European rabbits, determined that projectile energy and shooting distance were key in determining the welfare outcome for wildlife being shot. They found that increasing distance led to poorer welfare outcomes in the use of two .22 calibre bullet types (particularly for the 198 joules .22 long rifle rimfire bullets when compared to the 1433 joules .222 Remington centrefire bullets). In Scotland the Seal Management Code of Practice specifies that seals should be shot from a distance of 150m or less, although the marksmanship test only tests shooting ability up to 100m (Marine Scotland, 2011; SQA, 2011). This discrepancy may need addressing to ensure that marksmen are capable of accurately hitting a seal at the distance allowed in the Code of Practice.

Hampton *et al.* (2016) suggested that bullets with a higher energy profile provide better animal welfare outcomes, and they recommend that wildlife shooting programmes should specify projectile energy rather than firearm calibre to ensure an immediate death. Aebsicher *et al.* (2014) also found that bullet weight and energy were more important than calibre, and that wounding rates of deer were lower with heavier bullets. Brownlow (2016) stated that the kinetic energy of the projectile will be reduced as the bullet passes through the turbinate bones and, therefore, it is important to choose bullets that retain enough energy to destroy the cranial vault. An international standard for recommended firearm and bullet type could ensure improved welfare for shot seals.

What about other seal killing methods? NAMMCO (2009) suggested that levels of suffering of seals caught in nets cannot be assessed due to a lack of available data, but EFSA (2007) concluded that suffering was likely to be prolonged, and that seals dying in nets clearly experience a protracted death. The negative impact on seal welfare will be increased if the seal becomes entangled in the net as it will experience stress due to the restrictions on its behaviour and physiological choices (EFSA, 2007). A review of drowning as a method for killing beaver and other animals determined that drowning can take minutes to cause death and results in pain and distress (Ludders *et al.,* 1999). Due to their specific diving adaptations, seals do not lose consciousness quickly if trapped underwater in a net, and could, in fact, remain conscious until death; a process which could take tens of minutes and, potentially, over an hour in some cases (EFSA, 2007). The NAMMCO Coastal Seal Working Group has recommended that the method of catching common seal pups in nets in Iceland needs to be investigated to ensure that it fulfils the NAMMCO requirement that killing methods should result in an immediate death (NAMMCO, 2016a). The NAMMCO Management Committee for Seals and Walruses noted that new legislation prohibiting the drowning of animals might have an impact on this method of seal killing but that clarification is needed (NAMMCO, 2017b).

In Greenland, netting is considered beneficial to hunters because seals are rarely lost using this hunting method (Garde, 2013). However, NOAA (2007) classified asphyxiation as being in the "*severest*" classification for welfare impact. Netting and harpooning are hunting methods which do not aim to destroy the brain and are likely to negatively affect the welfare of the seal or walrus before it

becomes unconscious (EFSA, 2007). NAMMCO (2006) recognise that killing times need to be minimised in walrus hunting with harpoons, but that the safety of the hunter and the risk of losing the animal also need to be taken into consideration.

Bonner (1993) suggested that clubbing is as humane as shooting when killing seals. Daoust and Caraguel (2012) pointed out that clubbing has an advantage over shooting in that the hunter is next to the seal and able to immediately check whether the animal is properly stunned before bleeding out. However, despite this possibility, there is evidence from the commercial harp seal hunt in Canada that the majority of animals are not assessed via blinking reflex tests and/or cranial palpation after they have been clubbed or shot (Butterworth *et al.,* 2007). As the hunting methods in the commercial hunts undertaken by Norway, Greenland and Russia take place in similar conditions and using similar weapons to Canada, it is conceivable that in these hunts the state of consciousness of the seal is also not fully assessed.

EFSA (2007) considered bleeding out to be an essential part of the killing process to make sure that the seal dies a humane death. This does not take place in many situations where seals are killed in Europe mainly due to the conditions in which they are being shot i.e. in water near fish farms and fisheries. NAMMCO (2009) also recommended that, after stunning, seals should be killed by exsanguination or pithing (the physical destruction of the brain and upper part of the spinal cord) (OIE, 2017). Daoust and Caraguel (2012), on the other hand, considered that bleeding out is a precautionary measure and that by this point the seal should already be dead if the correct procedure has been followed. They were referring to the commercial hunt in Canada where seals should be killed or irreversibly stunned with a hakapik, club or rifle followed by checking, through external palpation of the skull, that the calvarium (skull bone, skullcap) is completely crushed (Daoust and Caraguel, 2012). If it is the killing method which should kill the seal, rather than bleeding out, then shooting (without subsequent bleeding out) could be considered an effective killing method but only if the shot is accurate and induces an immediate stunned state which then progresses to death without risk of recovery. This will not be the case in all shot animals, as the location of the seal at the time of shooting, the location of the impact, and the accuracy of the shot, may all influence whether the seal will experience a quick death.

How animal welfare is impacted by a particular killing method will depend on the capacity of the species to suffer, how long the pain, distress or suffering lasts, how intense the pain, distress or suffering is and the number of animals affected (Littin and Mellor, 2005). Broom (1999) proposed that no matter what reason for a human-animal interaction, there exists a human moral obligation to minimise animal suffering. So, whether a seal is killed for commercial reasons, for sport or to protect farmed fish or a fishery, the impact on the seal's welfare should be taken into consideration.

3.2 Location (land/ice or water) of seal at time of killing and position of marksman

The reasons for killing the seal and the necessity (or not) of retrieving the carcase have determined the location of seals when they are shot and, also, where the marksman is in relation to the animal at the time of shooting. Shooting seals when they are in the water could have serious welfare implications if (i) they are injured and then lost, and (ii) they cannot be properly seen when partially submerged in the water, adversely affecting the chance of an accurate shot. Some authorities have stated that "*shooting seals in open water can never be humane*" and that the chances of a poor welfare outcome are higher when seals are shot in water (Burdon *et al.*, 2001; Smith, 2005; Daoust and Caraguel, 2012). EFSA (2007) concluded that "*shooting animals where the likelihood of reaching them quickly is reduced or questionable (e.g. on thin and loose pack ice, open deep water), poses an unknown risk of causing avoidable pain, distress and suffering*."

In the Canadian harp seal hunt, it was found that shooting a seal in water meant a 30% risk of a poor welfare outcome compared to a 2.6% risk when the seal was shot on the ice (Daoust and Caraguel, 2012). As current practice in some countries, requires that seals be shot in water and, in the case of Scotland, it is specified on seal licences that seals must not be shot whilst they are on land (Marine Scotland, 2015; Marine Scotland, 2017a), there is clearly potential for seal welfare to be compromised.

Some European countries allow seals to be shot on land, which may well allow the marksman to have a better chance of making a clean shot. If seals are to be shot in water, then Bonner (1993) recommended that a marksman should shoot from a few metres above the water level to prevent a bullet from striking the water in front of a seal and being deflected upwards, causing a non-fatal wound. However, depending on the site and circumstance of the killing, the marksman may not have the option of being in an elevated position. Butler *et al.* (2008) pointed out that sea conditions around netting stations in the Moray Firth, Scotland meant that visibility was often poor. Shooting in such conditions could similarly have an adverse affect on seal welfare.

The stability of the marksman's position is also of importance. Some authors have recommended that rifles should not be used from boats to shoot seals in the water (Bonner, 1993; Smith, 2005). In Scotland seals must not be shot from an "*unstable platform*", which suggests that they should not be shot from boats, though "*judgement on these issues should be made in the opinion of the nominated marksman or licensee*" (Marine Scotland, 2011). The Code of Practice is thus open to significant interpretation by the person carrying out the shooting.

3.3 Open and close seasons

As highlighted in section 2.4, many European countries have close seasons to protect breeding seals. In Scotland, however, no dates are specified in the legislation for when seals can or cannot be killed, not even during the periods when females are in an advanced stage of pregnancy or feeding dependent pups. Grey seals in UK waters give birth to their pups in the autumn and have a

gestation period of about 240 days, whereas common seals give birth to their pups in June and July and have an average gestation period of about 270 days (Scottish Government, 2018; Scottish Natural Heritage, 2018). In both species there can be delayed embryo implantation (embryonic diapause), which can extend the period of pregnancy. Because both of these species produce young once a year, and have relatively long gestational periods, then it is possible, even probable, that some animals are pregnant, or even in the late stages of pregnancy when they are killed.

Nunny *et al.*, (2016) reported that 35% of the shot seals necropsied in Scotland between 2011 and 2014 were pregnant. Studies in Sweden have also found that female seals have been killed whilst pregnant. Moraeus *et al.,* (2016) reported that 81% of the sexually-mature female common seals that were killed during the gestation period in 2012 and 2013 were pregnant. In 2012, two of the five sexually-mature female grey seals killed and sampled during the gestation period were pregnant (Moraeus *et al.,* 2014). As noted, seals can exhibit embryonic diapause, a mechanism that allows control of the time of birth to coincide with favourable environmental conditions (Laws *et al*., 2003; Shero *et al*., 2018). For embryos held at this very early stage of development, there are not considered to be direct welfare concerns. A large proportion of adult females (80-90%) may be carrying a fertilised embryo at any time; with the embryo in embryonic diapause (very early stage pregnancy) or an actively developing embryo (second part of the pregnancy, post-diapause) during most of the year. In some regions, the amount of hunting which takes place during the time when females are in later stage pregnancy is less (for example Finland and Åland), but this is not the case in all areas. Coincidence of hunting with the later stages of pregnancy may vary regionally.

A recent report by EFSA (2017) indicated that there is a relatively small probability (1-33% likelihood) that foetal animals in the latter stages of gestation have the capacity to suffer as a result of the killing of the mother, based on interpretation of the electrical activity detected in the brains of foetal animals, and their ability to respond to external stimuli (EFSA AHAW, 2017). This conclusion was based on livestock and it is unclear whether the probability of foetal marine mammals feeling pain would be the same. With this uncertainty, we recommend that female seals in the latter stages of pregnancy should not be shot. Without close seasons, pregnant females and lactating mothers with dependent young can be targeted, with the associated negative welfare consequences such as dependent pups being left to starve to death.

3.4 Monitoring of seal killing and training of marksmen

Most seal killing for management reasons is not independently monitored and the recording of the number of seals killed relies on accurate reporting by hunters or marksmen. Despite requirements set out in the Scottish Seal Management Code of Practice, only a small percentage of the seals reported as shot to the Scottish Government from 2011-2014 were also reported to SMASS (Nunny *et al.*, 2016).

Commercial hunts are more likely to be independently monitored by veterinarians to ensure that seals are killed in the appropriate manner. In Scotland, the necropsy of seal carcases is a way to monitor animal welfare issues without actually witnessing the kill. However, in response to a questionnaire, 71% of seal licence holders who had shot seals reported that they had not recovered any carcases (Nunny *et al.*, 2016). Marine Scotland (2015) consider that carcases are not collected because they sink, are too heavy or are difficult to recover from rocky areas at the bottom of cliffs. If the welfare of shot seals is to be monitored, then more carcases need to be collected and necropsied. Incentives such as the compensation payments offered in some European countries could, potentially, encourage the collection or reporting of more carcases. However care also needs to be taken to ensure that such schemes do not promote killing for the receipt of a 'bounty' payment, which could exacerbate widespread seal shooting, as happened in Scotland in the 1990s (Butler, *et al.*, 2008).

The Ministry of Fisheries, Hunting and Agriculture (2012) in Greenland reported that seals that are shot before the summer are more likely to sink because of their physical condition and because of lower salinity in the water due to melting ice. NAMMCO (2006) similarly notes that typically fatter animals will float whilst thinner ones will sink.

3.5 Reducing conflict to protect seal welfare

To reduce the conflict between seals and fishermen and fish farmers, non-lethal approaches need to be improved and encouraged as much as possible. The Code of Good Practice for Scottish Finfish Aquaculture recommends that salmon farmers should "use appropriate and site specific methods to deter seals observed in the vicinity of their fish by using non-lethal methods" (CoGP, 2017). A series of measurements are recommended which should be employed to prevent seals from attacking fish.

The RSPCA has published a guide to welfare standards for farmed Atlantic salmon which states that "*humane precautions must be taken to protect salmon from other animals*" and that the farmer must use "*all reasonable non-lethal methods of control*" (RSPCA, 2015). The main way of protecting fish is by physically excluding predators and details of enclosure nets and predator nets are given (RSPCA, 2015). Fish farms that are at risk of predator attack must use an Acoustic Deterrent Device (ADD) and the RSPCA clearly states that before a seal is humanely killed, all non-lethal methods for protecting the fish should be in place and that shooting is a last resort (RSPCA, 2015). However, ADDs have been found to be effective in some circumstances but not in others (Graham *et al.,* 2009; Harris *et al.,* 2014).

Aquaculture businesses should plan appropriately to minimise conflict. However, it is reported that, in Norway at least, the distribution of seal populations has not been considered when the siting of a new fish farm was being decided (NAMMCO, 2016a). Within the EU the siting of marine fish farms has been contentious because of potential impacts on wild Atlantic salmon,

which are protected by the EU Habitats Directive (Butler and Watt, 2003). Both common and grey seals are also listed under the Directive and hence fish farm sites should also be considered in terms of their interactions with seal Special Areas of Conservation.

Can the killing of specific, 'rogue' or problem seals be justified because it protects a significant number of fish and, potentially, has a positive result for other seals? Studies have found that certain individual grey seals are specialist feeders which are more likely to feed on salmonids than the general seal population and that some seals even specialise in raiding salmon traps (Graham *et al.,* 2011; Königson *et al.,* 2013). In Finland and Sweden, such 'problem seals' are specifically targeted by fishermen and/or hunters (Baltic Marine Environment Protection Commission, 2016; Suomen Riistakeskus, 2016a). This approach could mean that non-nuisance animals are protected and that, perhaps, surviving animals learn to avoid humans (Treves and Karanth, 2003). However Graham *et al.,* (2011) point out that identifying problem seals in the field is difficult. Further innovation is required to develop non-lethal strategies to deter 'rogue' seals from potential conflict areas (Butler, 2011).

4. Conclusions

The deliberate killing of seals to protect fisheries and fish farms is a very controversial issue and raises grave welfare concerns as identified here and in Nunny *et al.* (2016). Others, such as Treves and Karanth (2003), have already recommended that carnivores should be managed using only non-lethal methods which modify their behaviour or through changes in human behaviour, and that lethal methods should only be a last resort. In line with Dubois *et al.* (2017), we propose that human practices be changed to prevent human-wildlife conflicts from arising in the first place and that a "culture of coexistence" be developed.

Properly managed lethal control of predators has been presented as a means to reduce threats to livelihoods without negatively impacting the conservation status of a species (Treves and Naughton-Treves, 2005). However, the welfare of individual animals also needs to be considered. This review, the first to examine practices comparatively across Europe, shows that there is no agreed international best practice for seal shooting for whatever purpose - indeed some practices are dramatically at odds with each other - and this needs to be addressed.

If lethal control measures are to continue, then good codes of practice and training are essential to ensure that shooting does not result in poor welfare (Broom, 1999). Other elements of good practice should include:

- annual (or at least regular) training and assessment of hunters;
- the implementation and enforcement of relevant legislation;
- increased effort to improve the efficiency of killing and this includes the expert and independent examination of carcasses, which should be retrieved for this purpose: and
- minimising conflict by locating fish farms away from core seal habitat.

One way to improve killing methods might be to systematically evaluate the welfare impacts of different methods. Such an assessment could form the basis for shared international understanding and legislation.

Acknowledgements

Thank you to the many people who provided advice to this review, including those who helped to clarify details and to the two anonymous reviewers who helped to greatly improve it. Thanks also to Claire Bass for commenting on an earlier version of this paper.

This research was supported by the Humane Society International but the views expressed here are purely those of the authors and may not reflect any organisation that they are associated with.

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